The Mysore Coffee Experiment Station—Bulletin No. 13

DEPARTMENT OF AGRICULTURE

MYSORE STATE

ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1934-35

IMPERIAL MYCOLOGICAL INSTITUTE
23 SEPT. 1935

BY

W. WILSON MAYNE, B.Sc.,

Scientific Officer to the United Planters' Association of Southern India

BANGALORE:

PRINTED BY THE SUPERINTENDENT AT THE GOVT. PRESS

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FOREWORD.

It has been customary to publish this report as a bulletin of the Coffee Experiment Station, as approved by the Executive Committee of the United Planters' Association of South India. A large amount of statistical data on the effect of spraying coffee against Leaf disease has been collected by the Coffee Scientific Officer. Though uniformity of results has not always been achieved owing to interference of various environmental and other factors, an attempt has been made to draw some tentative conclusions. While realising the difficulty involved in arriving at a correct estimate of spray values under estate conditions, the decision about deletion of the use of spreaders in spray mixtures may await till such time when more information is available.

B. Narasimha Iyengar,
Director of Agriculture.

ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1934-35.

I have the honour to present the Administration Report of the Coffee Scientific Officer for the year ending 31st March 1935, dealing with work in progress in connection with coffee problems.

As in previous years, the work has been centred at the Mysore Government Coffee Experiment Station, Balehonnur, under the direction of the Director of Agriculture. Work in co-operation with the officers of the Station has been continued in connection with breeding, spraying and miscellaneous problems.

The Assistant has continued to work in South Coorg but has been severely handicapped by malaria, which completely interrupted work in the last quarter of the year.

A commencement on the construction of a bungalow at the Experiment Station was made towards the end of the year.

The Report, as in previous years, comprises a short account of touring work, scientific investigations in progress and general notes on coffee problems which have been raised during the year.

I. Touring.

Two visits to S. Coorg were paid in connection with the work on eelworm and the establishment of supplies. The progress in this work will be dealt with in a later section of the report. During the visits, three demonstrations of the technique of grafting were given which were attended by a number of estate managers and subordinates.

The Nilgiris and the Billigirirangans were visited in June 1934, in connection with problems of disease control. Reports were prepared for the estates visited.

The Annamalais were visited in January 1935 to investigate a disease which was causing alarm. The symptoms and conditions did not suggest that any parasitic disease was involved, and it was concluded that

unfavourable soil conditions coupled with an especially dry cold weather and small North East rains had resulted in severe damage to coffee root systems which were found to be almost entirely confined to the surface soil. A report was submitted to the estates in question.

II. Investigations.

Leaf Disease—Progress Report.—Work on Leaf Disease during the year has been almost entirely concerned with studies of resistance and susceptibility of various families of plants available at the Station, and with the improvement of the inoculation technique. Results are accumulating but are still insufficiently numerous for detailed discussion.

It seems that resistance to Strain I (that to which a considerable proportion of Kent plants are resistant) is a simple Mendelian dominant. Resistance to Strain II is still obscure and has so far only been found associated with resistance to Strain I in plants which are probably of hybrid origin. No case of a plant resistant to Strain II and susceptible to Strain I has so far been discovered. The offspring derived from one plant by self-fertilization showing complete resistance in the field gave only three types with respect to Leaf Disease,—resistant to both strains, like the parent, resistant to Strain I only, like a typical Kent and susceptible to both strains, like the ordinary Coorg. A second family derived in the same way from another completely resistant plant gave only two types, one like the parent and one like the ordinary Coorg.

In studies of this description, where the interpretation of results depends on a statistical analysis of data, progress is necessarily slow as a large quantity of data must be accumulated before results can be stated with certainty.

As a point of interest, it may be pointed out that plantings of "Kent's" may, and usually do, contain plants whose disease behaviour is like that of Coorgs, as well as plants which show typical "Kent" behaviour in this respect. At the same time it would be possible to plant an isolated seed garden which would give plants showing complete uniformity with respect to this character from material at present available at the Experiment Station.

It is hoped from some material available to find out whether the difference in disease behaviour between different Kent plants derived from the same parent is at all reflected in productivity.

Die Back—Progress Report.—Further work on this disease during the year has failed to establish the part played by the fungus *Colletotrichum coffeanum* (*Glomerella cingulata*) which is invariably isolated from attacked tissues but progress in the investigation is not without interest.

Cultural Work.—Attempts to isolate fungi from die-back shoots have confirmed previous work. *Colletotrichum coffeanum* is invariably isolated from attacked shoots and is frequently the only fungus obtained. Isolations from shoots showing the very earliest external symptoms always gave the same organism.

A study of the organisms present on the surface of completely healthy coffee shoots in October showed that the fungus is present, presumably in the spore stage, on healthy green wood, along with a number of other fungi. Similar studies in February and March, while showing a very high fungus population on the surface of such shoots, did not reveal the presence of *Colletotrichum.*

The presence of the fungus commonly on the surface of completely healthy shoots, in a season when other shoots are dying back, suggests that the fungus is not a primary active parasite and supports the early view that certain predisposing conditions are a necessary precursor of the disease, if it plays any part other than hastening the death of shoots, already seriously debilitated by physiological causes.

Inoculation Experiments.—A considerable number of experimental inoculations were made during the year both in the laboratory, on detached shoots, and in the field.

i. *Laboratory Inoculations.*—The results of these experiments were inconclusive. Shoots developed symptoms of die back in both inoculated and control series, but only in one case, where the inoculation was carried out on a fresh wound, were the symptoms first visible at the point of inoculation. In the other cases, symptoms always appeared either at the points from which a leaf had fallen during the experiment or at the base of the shoot immersed in water. Isolations from such shoots usually produced a mixture of bacteria and *Colletotrichum* but a pure culture was obtained from the shoot in which symptoms arose at the point of inoculation.

In view of the results of isolations from healthy shoots the presence of *Colletotrichum* in these cases is not a matter for surprise. The only conclusion is that methods of surface sterilization of the shoots prior to inoculation were not satisfactory.

(*ii*). *Field Inoculations.*—These were carried out in view of the difficulties met with in trying to keep cut shoots healthy in the laboratory. The points of inoculation only were surface sterilized and the appearance of symptoms elsewhere on the shoot were taken as due to uncontrolled causes. The results were again inconclusive. Shoots died in both inoculated and control series and in only one case did the symptoms appear at the point of inoculation. This case was of a shoot inoculated at a leaf scar, and symptoms of Die Back did not appear until 41 days after inoculation, though a slowly extending area of blackened tissue around the scar was noted as more marked than the usual scar blackening on the 18th day.

The experiments did not include a series of inoculations on fresh wounds but this is planned for the coming year. It was noted that in tissues of scars at the stage at which inoculations were carried out, a corky layer was already formed and this may present a barrier to invasion. With the fungus commonly present on healthy shoots, it may be that it is able to take advantage of the first weakening of the tissues at the leaf base before the abscission layer is fully formed. Before the fungus can be definitely ruled out as an important factor in the causation of Die Back, it is necessary to prove the inability of the fungus to invade fresh wounds and to study the rate of healing of leaf scars, which are the commonest wounds, in relation to the possibility of infection by this route.

It may be remarked that inoculations were carried out both with spores from pure cultures of *Colletotrichum* and with spores derived from Die Back shoots kept in a moist chamber for 48 hours. The idea was to test whether the probable mixture of organisms so derived might be more pathogenic than pure cultures. The results were, however, equally inconclusive. This section of the work again suggests that the fungus is not an active primary parasite. There does not seem to be any support for the suggestion that a specially virulent strain of *Colletotrichum* is involved.

Field Observations.—In the course of the field inoculations, which involved almost daily examinations of the

shoots involved in the experiments, a certain number of the shoots developed symptoms of Die Back, and though these, with the one exception noted above could not be referred to the treatments, they afforded details of the development of the disease.

In every case the first signs of blackening always occurred at a node. Frequently a certain amount of blackening, sometimes accompanied by a splitting of the tissues, occurred immediately below the leaf scars without, however, involving more than a few square millimetres of tissue. In some cases, the decay extends accompanied by the yellowing of the green internodes. This is rapidly followed by a brown mottling of the internode surface, the brown areas being somewhat sunken; the mottling extends and darkens until the internodes progressively blacken and the shoot dies. The death is frequently arrested at leaf bearing nodes older than that at which symptoms appear, but leaves at younger nodes are shed and the shoot dies up to the apex.

The development of the symptoms after the first visible appearance of signs of the disease is very rapid, a shoot apparently healthy, though having lost some younger leaves may be quite dead within a week.

The observations suggest that premature leaf fall is, as was previously thought, the primary predisposing factor in the development of Die Back attacks, though it is clear that complete defoliation is neither necessary for, nor inevitably followed by Die Back.

It is obvious that Die Back is a complicated condition in which many factors are involved and that we are far from a clear conception of how it comes about. It seems clear that it is not a simple parasitic disease and its control depends on a thorough understanding of the various contributory factors. While the dying back of young wood seems most commonly to follow from premature leaf fall from Leaf Disease, there is no doubt that similar symptoms may follow a large variety of unfavourable growth conditions but the sequence always appears to be premature leaf fall and shoot decay.

Any factors which tend to the retention of leaf are likely to reduce the severity of Die Back. This is most obvious in the case of spraying, but it is clear in some cases that this treatment alone is insufficient. In such cases, it is frequently found that soil conditions are unfavourable, especially in the direction of limiting root development.

In general, whatever may be the final outcome of work directed to clear up the part played by the fungus, the control of the disease lies in the amelioration of the contributory factors, rather than specifically direct measures against the fungus.

Work on Spray Materials and Methods.

Type of Spray.—The field observations on the efficacy of different types of spray have been carried out as in previous years. Owing to the substitution of new mixtures for older ones and to the addition of some other new mixtures to fresh plots, it is most convenient to consider first those materials which have been under test continuously since the experiments were started. These are Casein, Linseed Oil 10 ozs. Resin Soda and Plain Bordeaux and Burgundy with Fish Oil Soap. The results for 1934 are given in table I.

Table I.

Leaf Amounts and Percentage Infection. Different Types of Spray, 1934.

Spray		*Leaves per Shoot*	*Percentage Infection*
Casein Bordeaux	...	4·89±·24	42·3 per cent
Plain Bordeaux	...	4·91±·20	49·3 ,,
Resin Soda Bordeaux	...	5·15±·23	35·8 ,,
Fish Oil S. Burgundy	...	5·46±·23	37·5 ,,
Linseed Bordeaux (10 oz)	...	5·49±·25	37·1 ,,
Control, Unsprayed	...	2·05±·21	86·6 ,,

None of these differences can be regarded as significant; the slightly higher percentage infections and lower leaf amounts in the case of the Casein and Plain Bordeaux records are partly due to a local increase in disease severity in one of the three plots of each treatment. These two plots were close together. It is difficult to account for this as in previous years the individual plots of each treatment have usually shown a close agreement. A possible source of such increased incidence of disease may be some alteration in shade.

These mixtures have been applied twice a year for five consecutive years (except Bordeaux without adhesive, which was first applied in 1931). Comparing the plain Bordeaux with Casein Bordeaux and Linseed Oil Bordeaux, in only one year, 1931, is there a difference in favour of the adhesives which can be regarded as at all significant?

Owing to the fact that the plots sprayed with Plain Bordeaux had a slightly different previous history, having been sprayed with an ineffective mixture, Solbar, in 1930, too much reliance cannot be placed upon it. In the case of the other sprays mentioned, no year has shown a significant difference in favour of the use of the adhesives or spreaders.

The new materials which have been tested are given in Table II, together with the data collected and the number of seasons they have been in use, a season including a May and September spray.

TABLE II.

Leaf amount and Percentage Infection. New Spray Mixtures 1934.

Spray mixture	*Leaves per shoot*	*Per cent Infection*	*Seasons used*
Jingelly Oil (10 oz) Bordeaux	5·49±·18	25·5	2 seasons
Jingelly Oil (40 ozs) Bordeaux.	5·84±·23	28·1	1 season
Sodium Linoleate Bordeaux	4·90±·17	34·2	1 season
Sulphemulsol 2 per cent	1·35±·14	84·1	1 season
Groundnut Oil (80 oz) Bordeaux.	5·42±·20	31·9	1 season
Honge Oil (20 ozs) Bordeaux	5·39±·22	46·5	1 season
Groundnut Oil (20 ozs) Bordeaux.	5·41±·23	41·5	1 season
Jingelly Oil (20 ozs) Bordeaux.	5·06±·21	41·3	1 season

These data must be considered in three groups. The first two, Jingelly Oil 40 and 80 ozs with Bordeaux, cannot be compared with the remainder as, owing to the omission of a spray in May 1932, their whole rhythm of cropping has beed altered, and consequently direct comparisons, even for the amount of Leaf Disease and leaf retention, cannot safely be made. It is of interest to examine the alteration as indicating the enormous influence of spraying on cropping, and the figures of yield are given for three sets of plots in Table III. These three include the plots sprayed with Linseed Bordeaux 10 ozs, which has been regularly treated and the two series of plots now sprayed with Jingelly Oil Bordeaux, which suffered the omission of the May spray in 1932. The yields are in lbs. of ripe cherry per acre calculated from the mean yield of each set of three plots.

Table III.

Yields of Sprayed Plots previous to, and following the Omission of a Spray in May 1932.

	Yield per acre in lbs of ripe cherry				
	1930–31	1931–32	1932–33	1933–34	1934–35
Lin. Oil Bord. 10 ozs.	563	2659	2830	3047	573
Jing. Oil Bord. 40 ozs.	537	2835	2651	731	1424
Jing. Oil Bord. 80 ozs.	589	2435	2454	863	1864

It may be pointed out that the course of the yields in all the sets of plots which have been sprayed regularly with Bordeaux or Burgundy mixtures were essentially of the same order as those given for Linseed Oil Bordeaux in Table III. As no leaf counts were made in September 1932 in the plots unsprayed in May 1932, no comparisons can be made that year with respect to leaf retention. It was, however, obvious to the eye that they lost as much, if not more leaf than the controls.

It is thus clear that direct comparisons of data for these plots with those from continuously sprayed plots must be made with some reserve. The leaf retention in in 1934 shows no outstanding features in these two plots but both show a rather markedly less percentage infection which is of some interest and worthy of further study.

The next three sprays, Groundnut Oil 80 ozs. Bordeaux, Sodium Linoleate Bordeaux and Sulphemulsol can be compared with the earlier series given in Table I as their previous history is essentially the same, having been sprayed with mixtures differing little, if at all, in effectiveness from those given in that table.

Sulphemulsol shows itself of no value against Coffee Leaf Disease at the strength used and in addition, it caused some burning of young foliage. Taken together with earlier results with Sulphur containing sprays, it seems that Sulphur is not a satisfactory fungicide against Leaf Disease. The other two sprays show now differences from the other sprays already discussed.

The last three sprays were applied to new plots added to the previous experimental areas and were previously sprayed with a standard general spray. Unfortunately the further extension of the area introduces a large positional variation, which seriously affects one plot of each set of three. The figures given are based on two plots only to

each treatment, which judging by the controls are under similar environmental conditions to the older plots. They also show no outstanding features.

The general tendency of these results is to suggest that there is little to be gained in the use of an adhesive or spreader of the types tested in spraying against Leaf Disease. This statement must be interpreted as strictly referring to spraying against Leaf Disease. It seems clear that in any discussion of the use of adhesives and spreaders, the disease against which the spray is to be used must be taken into account. If this is done and it is realized that such additions to the spray depend for their effectiveness not entirely on physical improvements to the mixture but on other factors determining the efficiency of the disease, many conflicting opinions recorded in spraying literature may be resolved. It is well established, for instance, that in the case of spraying against Arecanut Koleroga an adhesive or spreader is necessary for successful results. It may be that the same is the case in spraying against coffee Black Rot, but these data throw no light on the problem as Black Rot does not occur in the area in question. Where the disease to be controlled is Leaf Disease, the results of these experiments suggest that an adhesive or spreader adds very little to the degree of control.

This is not to say that the additions do not improve the physical properties of the spray mixture. These experiments throw no light on that question at all. All that can be legitimately concluded is that any improvements that such additions confer on the physical properties of the spray are prevented by other factors in the case of Leaf Disease, from being reflected in improved control detectable by the methods of observation. It is difficult to explain the failure of response to additions to the spray which laboratory tests and experience against other diseases suggest should improve the spray deposit, but it may lie in the relatively very low level of efficiency of spraying against Leaf Disease. In spite of the marked economic results from spraying against Leaf Disease, it must be admitted that the losses of leaf before reaching maturity are very high even where spraying is carried out. Some data collected in another connection show losses of leaf formed in the hot weather of 57 per cent before the middle of November, *i.e.*, within six months of formation. In the past four years, these losses were 44 per cent

in 1931, 20 per cent in 1932 and 57 per cent in both 1933 and 1934, though the area in question was sprayed twice a year in May and September each year, and showed a very marked increase of crop over the controls.

This low level of efficiency is due to the difficulty of effecting a complete spray cover to all the leaves, owing to the difficulties of timing the spray and applying it under estate conditions. These factors bulk so largely in spraying against Leaf Disease that the small improvements due to the addition of an adhesive are insignificant in comparison with other deficiencies. Where the level of spraying efficiency is higher, these small improvements may be of value.

It must be admitted that improvements sufficient to make the addition of an adhesive of practical value would not need to be very great. An increase of, say 5 per cent on a 3 cwt. crop would amply pay for the use of an adhesive or spreader but these experiments would be quite unable to demonstrate such a small difference, owing to the magnitude of the sources of error.

In concluding this section, it may be said that there is strong evidence from other sources that additions to spray mixtures of the types studied do improve the mixtures. These experiments show that such improvements are not reflected in an increase in Leaf Disease control detectable by the methods available, but at the same time the methods are not sufficiently sensitive to detect differences which would yet be economically satisfactory, in view of the relatively small additional cost incurred. Furthermore, the loss likely to be incurred by the omission of an adhesive or spreader is not likely to be very great.

The difficulty of giving advice on the use of adhesives is very great. Thus, even if a small gain is likely from the use of adhesives, it is possible the money spent might be better employed. For example, assuming the cost of an adhesive works out at Re. 1 per acre, the omission of the adhesive on a 200 acre estate, assuming two sprays a year, would be sufficient for the purchase of another sprayer. The improvement in spraying at the most favourable times possible with an extra machine, is likely, in my opinion, to outweigh any slight decrease in efficiency resulting from the omission of an adhesive. In considering this question, I think the first consideration should be; is the estate working the maximum number of

spray pumps for which water and coolies can be provided ? If not, then money spent on adhesives would probably be better employed in the purchase of further pumps until the maximum number that can be worked is available. Then, the possibility of improvements from the use of adhesives or spreaders can be reconsidered. This is not of course, a full consideration of the economics and costing of such a procedure, but merely an indication of the relative importance of the use of an adhesive or spreader and of the possibility of more profitable distribution of expenditure, until the maximum area can be sprayed in the shortest space of time.

Sprays and Dusts.—Observations of the same type as those outlined above were made on plots laid out on an estate in Coorg, in which a proprietary copper dust was tested against a Bordeaux spray. The results are given in Table IV.

TABLE IV.

Leaf Retention and Percentage Infection. Dust and Spray.

Treatment.	*Leaves per Shoot.*	*Percentage Infection.*
Linseed Bordeaux . .	6·75±·31	51·1
Copper Dust. ...	5·31±·29	73·4
Control Untreated . .	4·49±·32	87·6

The difference in favour of the spray is definitely significant in the case of both leaf retention and of percentage infection. There is a slight but definite difference in favour of the Dust over the Control in the case of percentage infection but the difference in leaf retention is only barely significant.

This set of observations tends to support the view regarding the possibilities of dusting previously published. It is hoped to obtain further data from a similar experiment in the coming year.

Time and Strength of Spray.—Observations on the period of application and on the strength of mixture have been continued as in previous years. They do not alter the general conclusions reached in previous years but are interesting in the light they throw on seasonal behaviour of the disease. The results of the observations are given in Table V.

Table V.

Leaf Retention and Percentage Infection.· Time and strength of Spray, Sept. 1934 and Feb.—Mar. 1935.

	Leaves per Shoot Sept. 1934.	*Percentage Inf. 1934.*	*Leaves per Shoot Feb. Mar. 1935.*	*Percentage Inf. 1935.*
Control I ...	1·39±·14	81·2	2·52±·16	44·7
One per cent May and September.	3·78±·20	55·8	3·36±·17	39·5
Control II ...	1·97±·17	81·4	2·06±·14	47·9
One per cent May only.	5·47±·22	45·5	1·99±·14	30·4
Control III ...	2·37±·21	82·1	1·74±·12	39·5
Half per cent May and September.	5·49±·20	57·3	1·88±·13	35·0
Control IV ...	2·77±·17	80·6	1·02±·08	52·9
Half per cent May only.	6·34±·18	42·4	1·14±·08	49·2
Control V ...	2·77±·26	77·3	1·84±·12	20·5
One per cent September only.	1·94±·16	59·8	4·11±·17	14·0
Control VI ...	2·19±·17	74·8	2·28±·17	24·7
Half per cent September only.	2·75±·22	64·4	2·77±·14	20·0
Control VII ...	1·99±·11	68·6	2·21±·14	36·0

There are one or two interesting features showing a variation from previous years. Considering the September observations, the one per cent May and September plot shows a very poor leaf retention compared with the other plots receiving a spray in May or May and September. As has been pointed out previously, this is due largely to environmental differences which are clearly indicated by the neighbouring control plots.

The main point of interest in the September observations is the slightly higher leaf retention and lower percentage infection in the plot sprayed half strength in May only, as compared with the plot sprayed twice at the same strength while the neighbouring control plots are in close agreement. The difference is, moreover, significant being more than three times the Standard Error. As up to the time of observation, both had received the same treatment—a May spray—the difference in behaviour must be the result of some previous difference. On examining the data for March 1934, it was found that the amount of diseased leaf present on the sampled branches was over twice as great in the twice sprayed plot as in the plot sprayed only in May. In other words,

there was more disease hanging about the trees in the dry weather in the plot sprayed twice than in that sprayed only once in May. To this fact may be attributed the difference noted. The possible importance of the September spray in causing retention of more diseased leaf through the dry weather and thus giving rise to more centres of infection in the following hot weather and early monsoon has previously been noted, but its significance has not previously been so clearly shown.

The probable reason for the clear demonstration in this year is that evidence suggests that the May spray was less successful than usual in covering a high percentage of new leaf, owing to the slow growth associated with the extremely dry hot weather. Consequently, the control of the initial stages of infection was likely to be less successful.

The areas sprayed only in September show, as in previous years, much the same loss as the control plots. There is a significant difference in favour of the ½ per cent sprayed plot over the 1 per cent plot which is not readily explicable. They showed no marked differences in March 1934 and have always in the past run closely parallel, while the controls do not suggest any marked environmental influences. A disagreement though completely reversed is shown in the February-March observations, for the same plots. The latter is probably the result of the former difference, as is suggested by the results of the other plots to be considered below.

The February data are interesting ; in that in nearly every case the plots most leafy in September are the least leafy in February. This is most noticeable in the control plots. If the control plots are placed in order of leaf amount in September, it is found that the order is almost completely reversed in February. This is shown in Table VI.

TABLE VI.

Leaf retention in September and February. 1934-35
Controls (numbers in brackets are the ranking).

				Sept.	*Feb.*
Control	IV	...	...	2·77 (1)	1·02 (7)
,,	V	...	...	2·77 (2)	1·84 (5)
,,	III	...	...	2·37 (3)	1·74 (6)
,,	VI	...	...	2·19 (4)	2·28 (2)
,,	VII	...	...	1·99 (5)	2·21 (3)
,,	II	...	...	1·97 (6)	2·06 (4)
,,	I	...	...	1·39 (7)	2·52 (1)

A comparatively simple explanation accounts for this. Owing to the extremely dry weather of the N.E. monsoon period, there was not a very severe increase in disease in October and November leading to further heavy leaf fall late in the year. Those plots which had lost a lot of leaf in September proceeded to produce a new flush which remained less affected by disease than usual, while the more leafy plots grew less new leaf in the same period but gradually shed older leaf which had been attacked by disease earlier. At the same time, the older leaf provided more centres of infection for the attack of new leaf when conditions permitted infection. It must be remembered that a large proportion of the leaf on the controls at the end of September was shed very shortly afterwards. An inspection of the plots in February showed quite clearly by the colour of the leaf that in the more leafy plots at that date, the greater part of the leaf was new, while the less leafy plots bore largely older leaf of a darker colour.

The combination of poorer protection with the May spray with conditions unfavourable on the whole for growth after the end of September, resulted in the twice sprayed plots half strength bearing the lowest amount of leaf in February since the observations were started.

The percentage infection data are a little confusing, as there is a sharp difference between the plots from Control I to half strength May spray and from Control V to Control VII. This is probably due to the retention of old leaf in the plots sprayed in May, which provided sources of infection for the new leaf in both these plots and their neighbouring controls, while the September sprayed plots which had thrown off a good deal of their diseased leaves in September and obviously dropped more in October and November had much fewer sources of infection during the latter part of the year.

It is impossible in this report to go into the full significance of all these figures, as it involves the consideration of the data from previous years. The most significant point arising clearly from this year's work is the great importance of the retained diseased leaf in initiating new attacks and interfering with adequate control.

It is hoped that the whole series of data will shortly be worked up into as full an account of the subject as the data permit. It is clear from the data collected that the expectations from spraying as at present carried out

depend to an enormous extent on the climatic conditions as they affect both disease and leaf production. Judging by the experience of the Station, the years when spraying was being extensively taken up, were on the whole favourable to success, while the last two years have been by no means so favourable. Moreover, the climate conditions leading to the poorer results indicated by these observations, were of fairly general occurrence, and it seems that the conclusions drawn are of more than purely local application.

Studies on Fruit Set and Development.

Crop Losses during Development.—The observations on loss of developing crop were carried out, as usual, during 1934 and a synopsis of the results are given in Table VII. The data for the previous years are also given for comparison.

Table VII.

Loss of Developing Fruit from Blossom to Harvest.

	1931.	*1932.*	*1933.*	*1934.*
Original Bud ...	9,031	5,379	6,768	5,310
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Loss—1st four weeks...	20·5	26·2	26·9	20·0
Loss—5th to 11th week	38·3	27·9	26·6	27·5
11th week to crop ...	4·2	4·5	7·9	22·0
Crop harvested ...	37·6	41·4	38·6	30·5

Two very striking differences are at once apparent, which differentiate the year from the three previous years; the proportion of buds which set fruit shows a very marked decrease while the fall after the 11th week shows a considerable increase. This reduction in set is undoubtedly referable to the extremely dry weather experienced in April and May 1934, and will be considered in more detail below.

The distribution of losses as given in the table is unsatisfactory, as they suggest that the greater loss occurred in the latter part of the development period. It appears from the detailed records that the time grouping which seemed fairly satisfactorily to correspond with developmental stages in previous years, did not do so in 1934. There was strong evidence of a very marked delay

in development which tended to make the periods of heavy loss much later in time. It is necessary to rearrange the data with respect to certain points of reference based on the development of the fruit, in order to permit direct comparisons. One point is quite clearly indicated—the first observation at which it is possible to distinguish by size, the fruits which will continue to develop from those which do not. As was pointed out in the report for 1931-32, a certain number of young fruit never develop into mature cherry but remain for varying periods up to harvest very little larger than they were shortly after blossom. The dates on which such differentiation was first possible are given in Table VIII, together with the dates of flowering.

TABLE VIII.

Date of Visible Differentiation of Swelling Fruit.

Year.	*Blossom*	*Difference visible.*	*Days.*
1931	3-4-31	12-5-31	39
1932	12-4-32	17-5-32	35
1933	11-3-33	27-4-33	47
1934	27-3-34	30-5-34	64

The date in 1933 is a little uncertain as blossoming was rather irregular as a result of the early showers which initiated flowering; the others, however, were fixed with a fair degree of certainty. Taking this visible differentiation as an index of the rate of development, it is clear that in 1934, development of the young fruit was very slow compared with previous years.

The second point of reference is not so easily defined but it may be said that of the remainder of loss, *i.e.*, of partly swollen fruit, practically all of it occurs in about six weeks following visible differentiation. During this period the fruits are increasing very rapidly in size, and afterwards, size increase is very small until ripening when the outer pulp tissues increase in bulk. Losses, where disease of the leaves and shoots are under control, after the slowing down of size increase are also small. In accordance with these groupings, a new table can be drawn up. For ease of discussion this year, 1934, is compared with 1932 as the original blossom amounts were approximately alike.

TABLE IX.

Distribution of Fruit Loss in 1932 and 1934 according to Development Stages.

	1932.	*1934.*
	Per cent	Per cent
1. Loss up to and including date of visible size diff.	31·2	37·3
2. Unswollen Fruit persisting ...	14·5	10·2
3. Loss 6 weeks following ...	11·4	20·0
4. Remainder lost after this period.	1·4	1·9

It is at once clear that the main difference in fruit loss lies in the fall of partially swollen fruit occurring about June. Moreover it is very interesting to note that the difference between the two years in final percentage set—10·9 per cent —is almost entirely accounted for by the difference in this 'June drop'—8·6 per cent. The main difference that could affect this dropping of young fruit was the extremely dry hot weather. It appears however that the dry season did not cause an increased loss directly by the 'burning off' of young fruit but that it exerted its influence through the nutrition and the availability of supplies in the months when the fruit was obviously making big demands on the tree. This follows from the fact that the increased loss was of young fruit which showed visible signs of increase in size.

These results are very suggestive and indicate that the investigation was well worth while. Results in temperate fruits show that these losses are not entirely uncontrollable. The successes in some fruits from the application of quick acting nitrogenous manures when growth commences in the spring or shortly after blossom on improving fruit set spring to mind in considering the data outlined above.

It may be pointed out that the difference in setting considered from the point of view of crop picked between 1932 and 1934 is roughly 25 per cent; in other words the blossom for a crop 25 per cent bigger was available at the time of flowering than was actually set. This, of course, assumes that the data are a fair sample of the crop in the area. In actual fact, as the observations take no account of the variation in amount of bearing wood present, they cannot be directly correlated with yield as a whole. It is certain, however, that this difference in set will lead to

marked reductions in the crop which might reasonably have been expected. This is borne out by the fact that over-estimates of crop were not uncommon last season.

The Study of Fruit Picked.—As in previous years, the fruit picked were cut open and the amount of various abnormalities recorded. These data are given in Table X.

TABLE X.

Analysis of Fruit Picked.

	1931.	*1932.*	*1933.*	*1934.*
Total Fruit	3397	2226	2611	1608
Per cent Peaberry	13·3%	21·5%	12·1%	14·9%
Per cent 3 beans in a cherry ...	1·0%	1·0%	1·0%	0·3%
Total No. of Beans	6376	4001	4874	2984
Per cent Empty Beans ...	2.0%	2·3%	1·7%	2·3%
Per cent Black Bean	11·9%	0·3%	17·0%	6·8%

Results follow much the same course as in previous years with the exception of Black Bean, which varies widely from year to year. It is not high in 1934, though higher than in 1932. It was found to be largely contributed to by just a few branches, and was not generally distributed through most of the branches under observation as in 1931 and 1933.

One interesting feature which has appeared in the study of these data in relation to the incidence of Black Bean is worthy of note here. As has previously been reported, there are reasons to believe that the conditions leading to this defect probably act about early August. It was noted that the branches under observation showed a much greater loss of leaf in August in the two severe Black Bean years than in the two lighter ones. This is clearly indicated in the graph on page 28.

It is true that in 1931, there did not seem to be any clear indications of a greater amount of Black Bean in unsprayed areas, which usually drop much more leaf than sprayed areas such as the area from which these data were derived. However, the facts noted are of interest as indicating a line of approach in the study of this defect. Further, records are, of course, desirable before one can conclude that a real causal relation exists between the two phenomena.

The amount of empty bean remains very constant at about 2 per cent of the beans harvested and does not seem to be greatly influenced by the size of crop or the climatic variations from year to year. The origin of this curious

abnormality has not been investigated but its importance does not seem to be great. Of the sources of loss of beans from the crop harvested, Black Bean is much the more important.

It may be noted that the presence of two embryos within one parchment—polyembryony—seemed more noticeable than in previous years, while three beans in a cherry showed some reduction. In 1932, polyembryonic beans occurred in 0·8 per cent of the fruit, while the corresponding figure for 1934 was 1·4 per cent. On the other hand three beans in a cherry fell from 1 per cent in 1932 to 0·3 per cent in 1934. These abnormalities are of relatively small importance practically, though they all go to swell the amount of triage in the total crop.

Laboratory Work on Fruit Development and Abnormalities. The amount of Black Bean during the year was small, in fact smaller than the data given in the preceding section might suggest. In an attempt to gather further data on the possible effect of manures on the incidence of Black Bean, about 500 fruits were examined without a single case being met with. These observations covered plots receiving Nitrogen alone, Potash alone and Phosphoric Acid alone and an unmanured plot. In consequence of this no further anatomical work on Black Bean was possible.

Attention was, however, again directed to the change of tissue in the bean which occurs usually in early August. The work confirmed in all essential respects the observations recorded in the report of 1932-33 and amplified them in some respects. It was amply proved that this change involves very intense physiological activity, the new tissue developing in the bean undergoing very vigorous cell division and multiplication. A full account must await further work as there are a number of points still very obscure with respect to the relations between this new tissue and the preceding tissue. It may be said, however, that there is no doubt that Black Bean is intimately related to this change of tissue and it is highly probable that some of the physical quality characteristics are also determined at this stage or shortly after.

Studies on Coffee Preparation.

Fermentation.—In continuation of the work reported last year, further cultural work was undertaken to isolate

and study the organisms involved in fermentation. The earlier work showed a predominance of yeasts in cultures but as these were all made at the end of fermentation, *i.e.*, from washing water or from the surface of washed parchment, it did not necessarily mean that they were the chief agents of the fermentation process. Further work involved the isolation of the organisms from samples taken at earlier stages in the process and these showed that the predominant organisms at this time are bacteria, of which one type in particular was isolated with great regularity. Tests made under sterile conditions showed it to be capable of cleaning the 'saccharine matter' from the parchment. Detailed study of the organism was interrupted and the cultures lost, but it is hoped to re-isolate it next season and study the conditions under which it works most effectively.

In view of the various notes that have appeared from time to time on the fermentation of coffee under water, it may be recorded that the bacterium isolated appeared to be equally effective when beans were just wet and when they were submerged.

Work on Nematode Worms and the Establishment of Supplies.

This work is in the hands of the Assistant and owing to his serious attacks of malaria was somewhat interrupted. There is, however, some progress to be reported. The work falls into two main sections, (1) the study of the Nematodes themselves and their fluctuations in the soil and their mode of attack, and (2) the possibilities of avoiding the damage caused by them by heavy manuring of supplies.

1. *The Study of the Nematodes.* Preliminary work on the parasitic Nematodes in the soil last year indicated that there were very large seasonal fluctuations and that in the dry weather, very few could be detected in funnel catches. Further studies of the Nematodes in the soil in the dry weather showed that while they did not appear in the funnel catches if the soil was taken dry and immediately extracted, after watering the soil worms could in practically every case, be recovered, frequently in considerable numbers. The region of greatest concentration appeared to be about nine inches depth while below a foot depth the

numbers decreased. In samples taken from areas known to suffer losses of young plants, a very considerable proportion of the worms were of the parasitic type. Detailed specific determinations were not possible, but the proportion of worms with the bulbed spear characteristic of the type found in diseased plants frequently made up 50 per cent of the worms obtained. The large proportion of larval stages in the isolations made from moistened soil in the dry weather suggests that the worms survive primarily as eggs during this period of the year. However, even in dry soils, quite shortly after moistening, adults are also found, suggesting the possibility of some adult resting stage.

Taking into consideration a great number of examinations of both soil in Nematode infected areas and of sickly plants, it seems that the worms leave the roots in the dry weather and either die, leaving eggs in the soil or enter a resting stage until increases in soil moisture allow fresh activity. It may be noted that the greatest numbers of worms obtained by moistening the soil in the dry weather are found below the level of the typical surface adventitious roots formed by attacked plants.

Attempts to breed worms in small soil samples by inoculating sterilized soil with known numbers of male and female worms have so far failed to produce results. It is obviously important to decide whether the worms breed freely in the soil and though this seems very probable, proof is desirable.

It is regrettable that inoculation experiments have proved disappointing. No clear case of the death of inoculated plants has occurred in experiments, though in one experiment in a root inspection box, ample evidence was obtained of the rotting of rootlets and of the presence of the worms in the tissues rotting. There are undoubted difficulties in inoculation experiments which are likely to take some time. The work of Bally and Reydon in Java showed that such experiments take a considerable time to develop. This work is being continued, with special reference to the possibilities of the acceleration of attack by the Mealy Bug which are frequently, but by no means invariably, associated with deaths of plants showing Nematode invasion.

For future work, it seems most desirable to find out the variations in Nematode activity in the monsoon with reference to time of planting. In connection with this a

series of observations on the percentage failure of plants planted at different times and using plants of varying age in Nematode infested areas were commenced but no results are available until next year.

2. *Manuring of Supplies in Nematode Infested Areas.*—Basing our views on the experiments of Dutch workers on the possibility of combating Nematode attack by liberal manuring of the supplies a series of experiments were started in the planting season of 1933 and a further series in 1934.

The series in 1933 involved the manuring at planting of young supplies with five mixtures or individual manures and measuring the growth increment. The data obtained from two of these experiments are given in tables XI and XII.

TABLE XI.

Manuring of Supplies at Planting 1933. Series I.

Manure.	*Ht. at Planting.*	*Increment in 2 months.*	*Increment in 14 months.*
N. only ...	5·9±·2″	3·1±·2″	13·9±1·0″
P. only ...	5·8±·2″	3·7±·4″	14·3±1·5″
K. only ...	5·4±·3″	2·3±·3″	11·8±0·9″
NP. ...	5·7±·3″	2·9±·3″	13·4±0·8″
NPK. ...	5·7±·2″	4·1±·7″	12·0±2·1″
Control. ...	5·3±·3″	3·8±·5″	11·8±1·0″

TABLE XII.

Manuring of Supplies at Planting 1933. Series II.

Manure.	*Ht. at Planting.*	*Increment in 2 months.*	*Increment in 14 months*
N. only ...	10·2±·3″	7·5±·4″	11·8±·8″
P. only ...	10·3±·3″	6·3±·3″	13·7±·8″
K. only ...	9·5±·3″	4·6±·3″	11·8±·7″
N. P. ...	9·5±·3″	8·5±·4″	14·3±·9″
N. P. K. ...	9·6±·5″	6·1±·4″	11·1±·9″
Control ...	10·7±·5″	5·9±·4″	9·6±1·3″

The results of the first series permit no very definite conclusions, but its indications in conjunction with the results of series II are interesting. In the latter series, there is a definite difference in favour of improved growth after two months over the controls in the case of Nitrogen alone and Nitrogen and Phosphoric Acid, while Potash alone

shows a reduction of growth when compared with the Control. After 14 months, Phosphoric Acid alone and with Nitrogen show an improved growth over the controls. Though the differences cannot be regarded as significant, the same treatments show greater growth than the controls in the series I, while Nitrogen alone is also good. Throughout, there is a general indication of a depression of growth by the application of Potash, though it only reaches a level of significance after two months in series II. Similarly, the complete mixture seems to show signs of less favourable results than Nitrogen and Phosphoric acid without Potash. It is interesting to note, also, that in both series, the loss of young plants in the course of the experiment was highest in the plots receiving Potash, either alone or with the other plant foods. The 1934 series also seems to show indications of depression of development with applications of Potash both alone and with the other nutrients. These experiments were on a small scale and tried under extremely severe conditions of Nematode infestation, while the 1934 experiments were tried under slightly less severe conditions. The results of latter will be considered in a later report.

Transferring attention to the amount of leaf and production of primaries, some interesting indications are obtained, though the data are insufficient for detailed statistical study. The figures are given in Table XIII, as primaries and leaves per plant.

TABLE XIII.

Leaf and Primary Production per plant in Manured and Unmanured Supplies. 1933, after 14 months.

Manure	*Series I.*		*Series II.*	
	Primaries.	*Leaves.*	*Primaries.*	*Leaves.*
N alone ..	3·2	24·7	9·7	44·3
P alone ...	3·5	24·1	9·1	57·3
K alone ...	2·4	19·9	6·6	38·4
N. P. ...	3·1	23·7	10·8	51·3
N. P. K. ...	3·4	24·2	8·6	36·6
Control ...	1·9	17·9	5·9	29·0

The indications follow the same course, as the measurements of height given in the previous two tables.

It is too early to discuss the significance of these results in relation to Nematode attack and the establishment of supplies in infested areas. The data, derived in

each case from 20 plants to each treatment, selected at planting for evenness are insufficient for any observations on comparative survival, and experiments on a much larger scale are necessary to study this point. It is, however, possible to eliminate some of the manures from large scale work. At the most, Nitrogen alone, Phosphoric acid alone or these two together seem worthy of further investigation.

From a more general point of view of supply or young plant manuring, it seems likely that a mixture without Potash is probably to be preferred to one containing it. Further information on this point will be available when the 1934-35 results are completely worked up. These must await the 14 month measurements which will become available in early 1935-36.

Future work of the Assistant is concerned with the further study of Nematode infection and soil population variation and with extended experiments on the effect of manures on supplies and observations of losses of young plants planted at different times and ages.

In addition to this work, an experiment on the control of Borer with Tar Distillate emulsion was commenced in Coorg. This was made possible by the kind co-operation of the Mysore Government Entomologist. Results will, however, not be available until next year.

A manuring experiment on adult coffee on an estate in Coorg was harvested by the Assistant. This experiment was designed to test different forms of Phosphoric Acid in complete mixture. The lay-out was a Latin square of 16 plots of 81 trees each, isolated by two foot trenches. The results of the first harvest reveal nothing, the experimental error being very much greater than any differences due to treatment.

General Notes.

The Year 1934-35.—The following general notes are based primarily on experiences at the Station supplemented by occasional reports from elsewhere. They may not be generally applicable to all coffee areas, but with variations, conditions follow much the same course in a large proportion of the area under coffee.

The most striking feature of 1934 was the very general drought conditions in the hot weather months.

Blossom showers were unfavourable in a number of places and were followed by a very dry April and May. Some of the effects of this have already been discussed in connection with investigations on spraying and fruit set. The effect of the dry hot weather was to delay the onset of Leaf Disease and up to the end of July, coffee was in excellent heart. The S. W. monsoon was, however, mild and broken, so that the advantage as far as Leaf Disease was concerned, was to a large extent counterbalanced by favourable conditions for disease increase during the monsoon. This became more serious as leaf growth in the hot weather was backward and spraying programmes failed to a great extent to cover a large proportion of the leaf produced. In consequence disease increased very rapidly in August and September and serious damage was done. The general impression gained was, that though conditions differed in almost every respect from 1933, the sum of effects led to a very severe attack of disease, as was experienced in that year. The maximum was, however, later in the year. The N. E. monsoon was very light indeed and drought conditions set in rather earlier than usual. This served to check growth after the monsoon and to some extent, the later development of Leaf Disease.

As a result of unfavorable conditions for wood retention in 1933 and of the dry hot weather of 1934, crops were on the small side.

There was fairly general rain in late January 1935 but the damage done was apparently less than was anticipated though it is difficult to tell what will be the fate of such blossom as opened with those showers.

The dry hot weather of 1934 led to a considerable increase in green bug. A case of serious attack of coffee by Thrips, a pest not previously reported as a serious pest of coffee in South was probably to be attributed to the same cause.

There is no doubt that the extremely dry N. E. Monsoon will lead to a severe attack of borer in the coming year.

On the whole, up to the end of year prospects for the coming year are favourable, though the limitation of growth in the hot weather and dry N. E. Monsoon may reduce the prospects in some areas owing to small supplies of bearing wood.

Diseases.—No new fungus diseases were reported during the year, but two cases of damage from other

causes received attention. The first of these was a leaf burn of Robusta. It chiefly affected the leaf edges which became brown and dry, but in severe cases it caused the loss of the whole leaf. Cultural work revealed a number of fungi commonly found on decayed tissues, none of which seemed likely to be an important factor. The cause was undoubtedly the drought. It seems clear that in establishing Robusta, adequate attention to the conservation of soil moisture is essential to success. This coffee species is very much more sensitive to drought conditions than Arabica.

The second case was of damage by Burgundy mixture. Occasional cases of this damage have occurred from time to time in the last few years and it seems clear that there is some risk attached to the use of this fungicide. The conditions leading to this damage are very obscure. Materials identical with those used in the damaged area failed to produce damage in experiments at the Station over quite a wide range of proportions. It is evident that damage only occurs under special sets of environmental conditions, but what these are, remains uncertain. Judging by experience with fruit trees, atmospheric humidity at, or shortly after spraying is probably an important factor.

In connection with Burgundy mixture, it was noted that the Potassium Ferrocyanide test is not reliable for free copper in the presence of particles of the Burgundy precipitate. When tests on the filtrate showed the absence of free copper, additions of Potassium Ferrocyanide to the mixture itself gave a brown precipitate, obviously by interaction with the particles. Bordeaux mixture differs from Burgundy in this respect.

Insect Pests.—The only new pest reported was a severe attack of thrips on the blossom of coffee in the hot wether in the Anamallais. Thrips are well known as a coffee pest in E. Africa, but do not seem to have been previously reported in South India. In dealing with this attack it was forcibly brought home that estates should keep a small stock af the common materials for dealing with such sudden outbreaks, as was recommeded by the Tea Scientific Department a year or two ago. The usual material for use against thrips is Nicotine, preferably as Nicotine Sulphate at the rate of one part in 600 or 800 parts of water or half per cent soap solution. Some recent work suggests that Paris Green in a three per cent molasses solution at the rate of one part of Paris Green in 800—1,200 parts of the solution is a better insecticide against

thrips, though there appears to be some slight risk of leaf burn. This insecticide has not been tested here, but as the materials are likely to be cheap, and as Paris Green is a common item in estate stores, it affords a convenient insecticide, worth testing against this pest. Incidentally, this might find some application in Cardamom cultivation where thrips appear to be occasionally serious. It must be emphasized that it requires trial as no experiments have yet been carried out locally.

It is probable that the attack is to be attributed to the dry hot weather experienced during the year, which favoured all sucking insects.

Correspondence, Publications, etc.—Three hundred enquiries were dealt with during the year, and as usual the majority were concerned with spraying and related problems, followed by manuring questions.

No bulletins were published during the year. Two articles were contributed to the 'Planters' Chronicle'; "The Root System of *Coffea Arbica*" being a review of a paper of that title by E. J. Nutman and "Some Notes on Burgundy Mixture and Burgundy Injury."

At the request of the Executive Committee, a note on the Investigation of Coffee Quality, indicating lines of approach to the problem, was prepared in conjunction with Dr. Shaw and Dr. P. Piekenbrock, to whom my thanks are due.

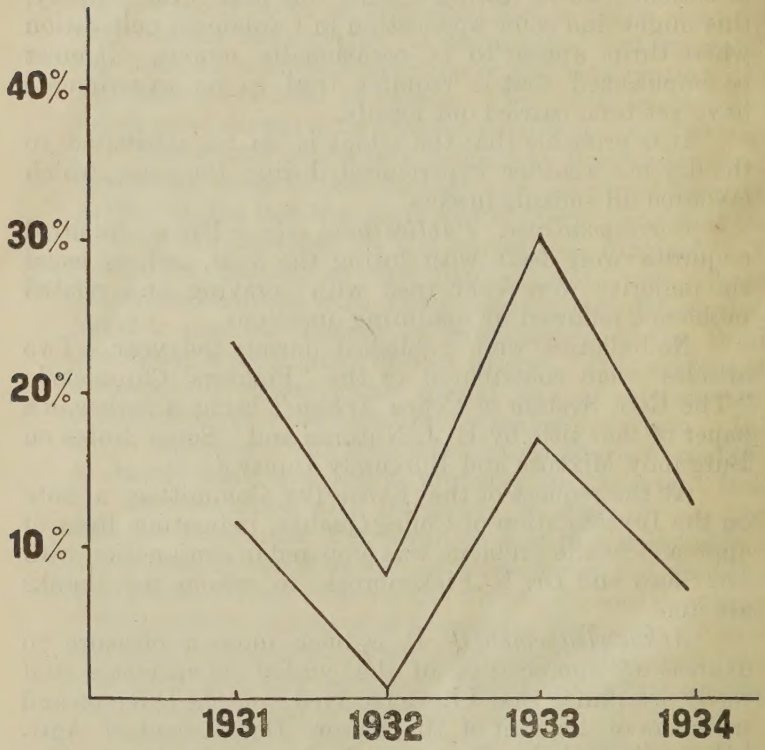
Acknowledgements.—It is once more a pleasure to express my appreciation of the cordial co-operation and ready assistance that I have received from the Director and members of the staff of the Mysore Department of Agriculture throughout the year. I also gladly express my thanks to the many planters who at various times have assisted me in co-operative experiments, in discussion and with hospitality.

A word must be said in praise of Mr. V. K. Subramanyam's devotion to duty, when suffering from severe recurrent attacks of malaria, which eventually necessitated his absence from Sidapur under medical treatment during the last quarter of the year. During this period, he was engaged on working up a mass of numerical data derived from earlier work.

W. WILSON MAYNE,
Coffee Scientific Officer,
U. P. A. S. I.

9th June 1935.

Graph showing Leaf Loss in August and Black Bean present in the Crop



Upper Line. Percentage Leaf Loss in August.
Lower Line. Percentage Black Bean in Crop.

WD 2125—GPB—1,000—3-8-35